High Temperature Thermochemical Heat Storage: Operation Modes of a 10kW Pilot Reactor based on $CaO/Ca(OH)_2$

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Content

- Introduction to thermochemical energy storage based on CaO/ $Ca(OH)_2$
- Material properties
- Reactor design and test bench development
- Experimental results of different operation modes
- Summary and outlook

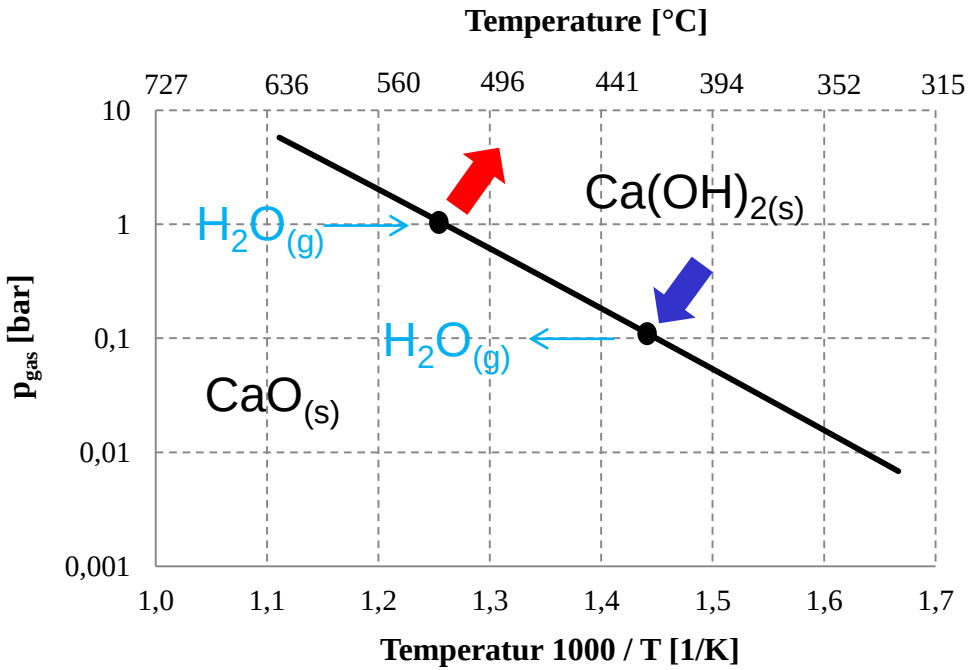
Thermochemical Heat Storage

reaction system $CaO/Ca(OH)_2$

exotherm

$$CaO_{(s)} + H_2O_{(g)} \rightleftharpoons Ca(OH)_{2(s)} + \Delta H$$

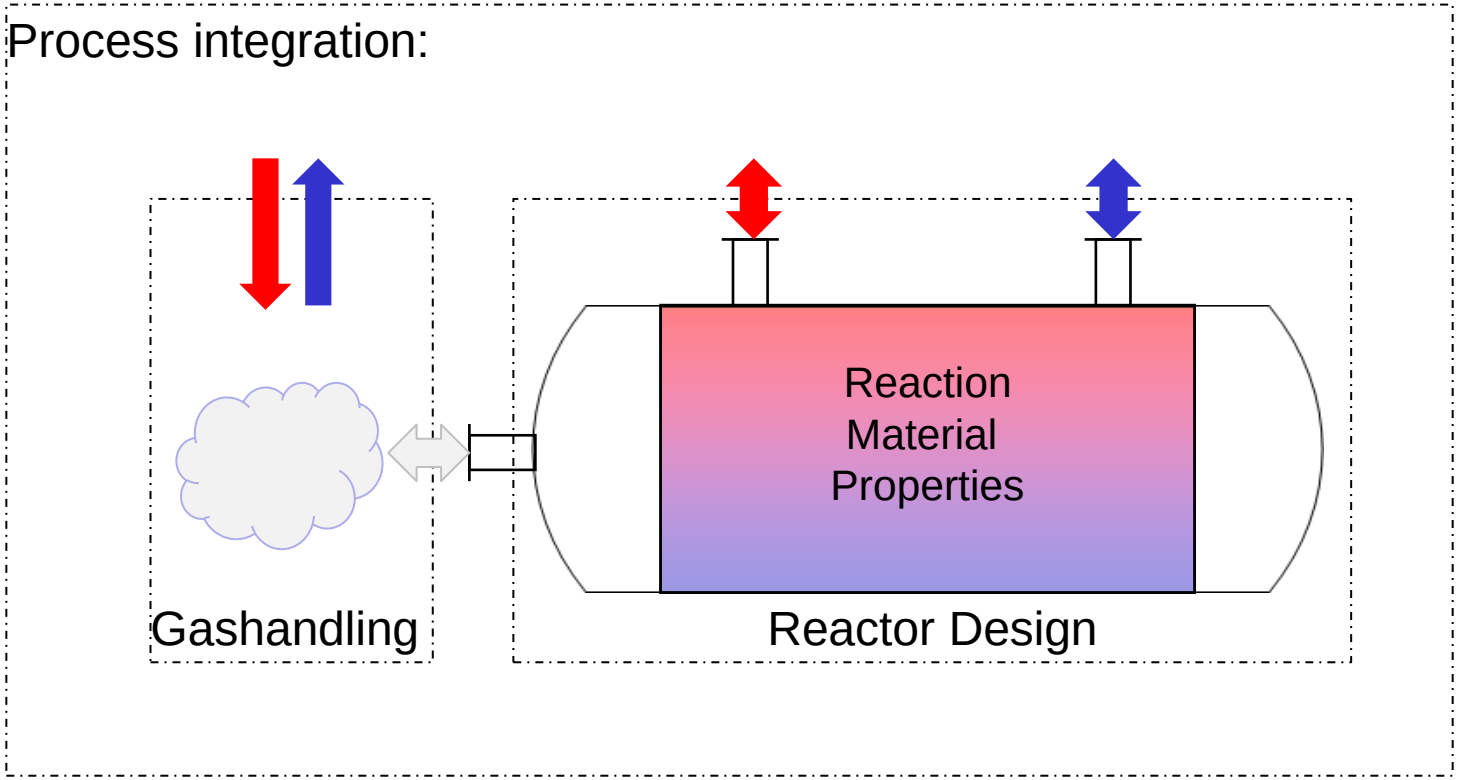
endotherm



- Loss free storage of chemical potential
- Adjustable storage temperature
- Possibility of heat transformation

From a reaction system to a heat storage system

operation principle



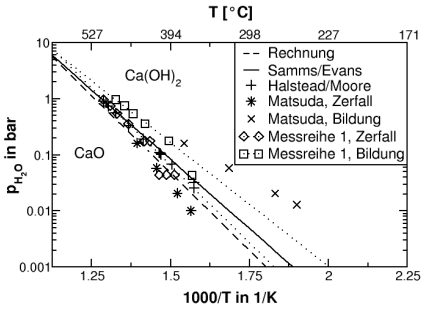
Material Properties - CaO/Ca(OH)$_2$

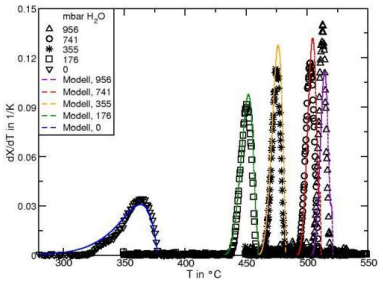
Chemical properties:

– Reversible reaction (400-600° C)

– Sufficiently fast rates of reaction

– No chemical degradation observed





F. Schaube et al., Thermochimica Acta, 2012

Thermophysical properties:

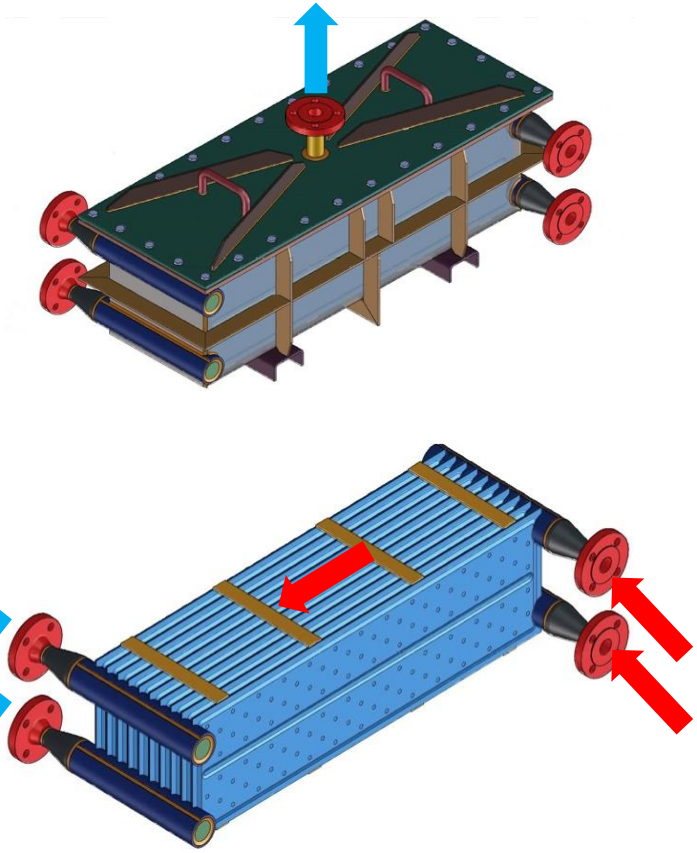
- Fine powder (d_{50} ~ 5 µm)
- low permeability
- Low thermal conductivity (0.1 – 0.4 W/mK)

commerical available Ca(OH)$_2$

Ca(OH)$_2$ (4 Cycl)

Pilot Reactor Design (10kW; 25 kg $Ca(OH)_2$)

indirectly operated fixed bed



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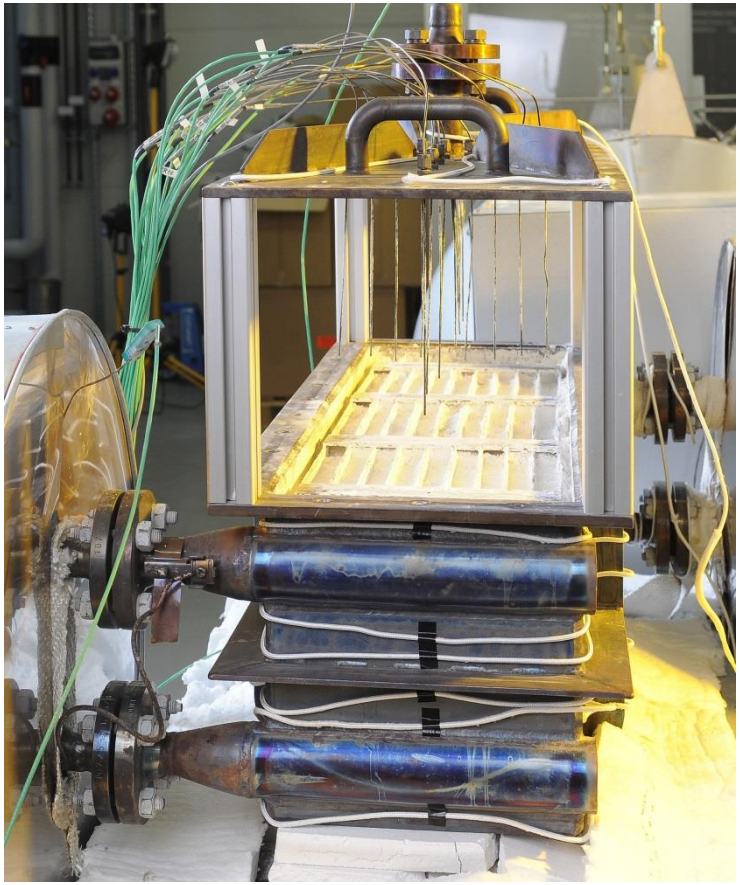
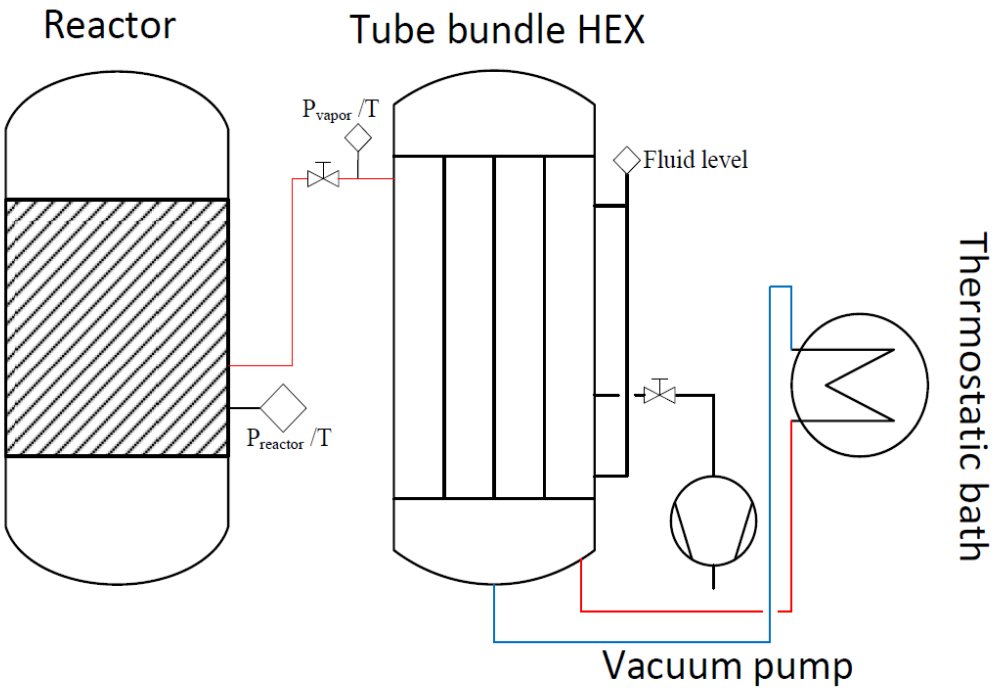


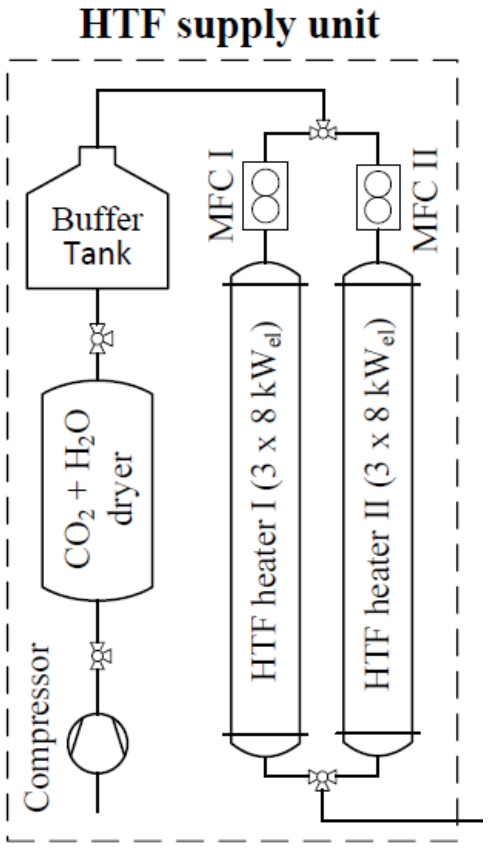
Reaction Gas Handling

vapor pressure holder(10mbar – 3bar)



Multifunctional Pilot Plant

overall experimental set up for $CaO/Ca(OH)_2$ reactor



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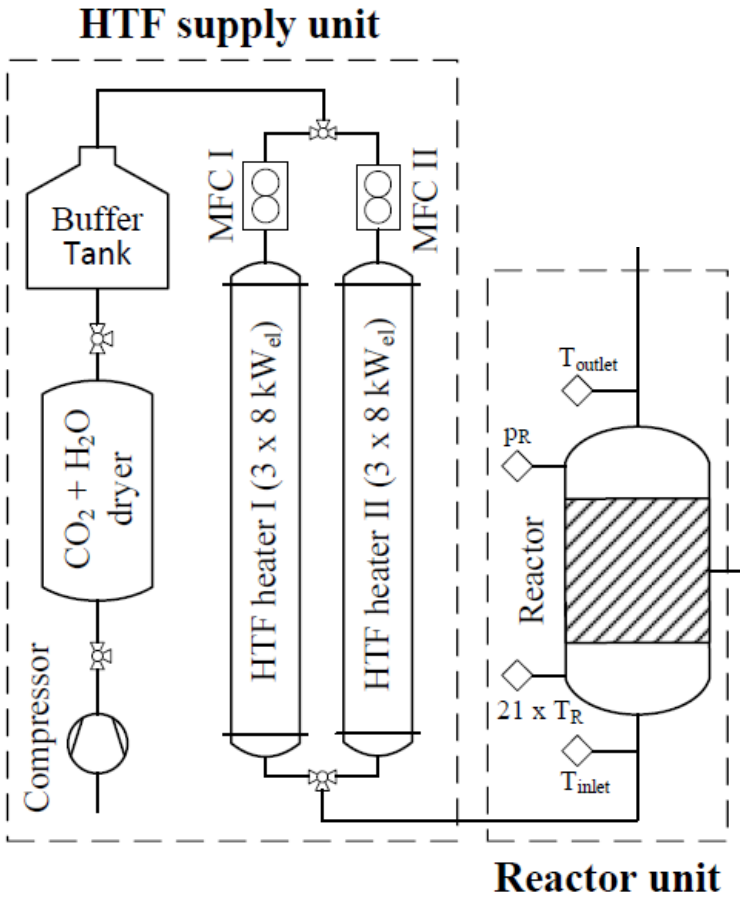

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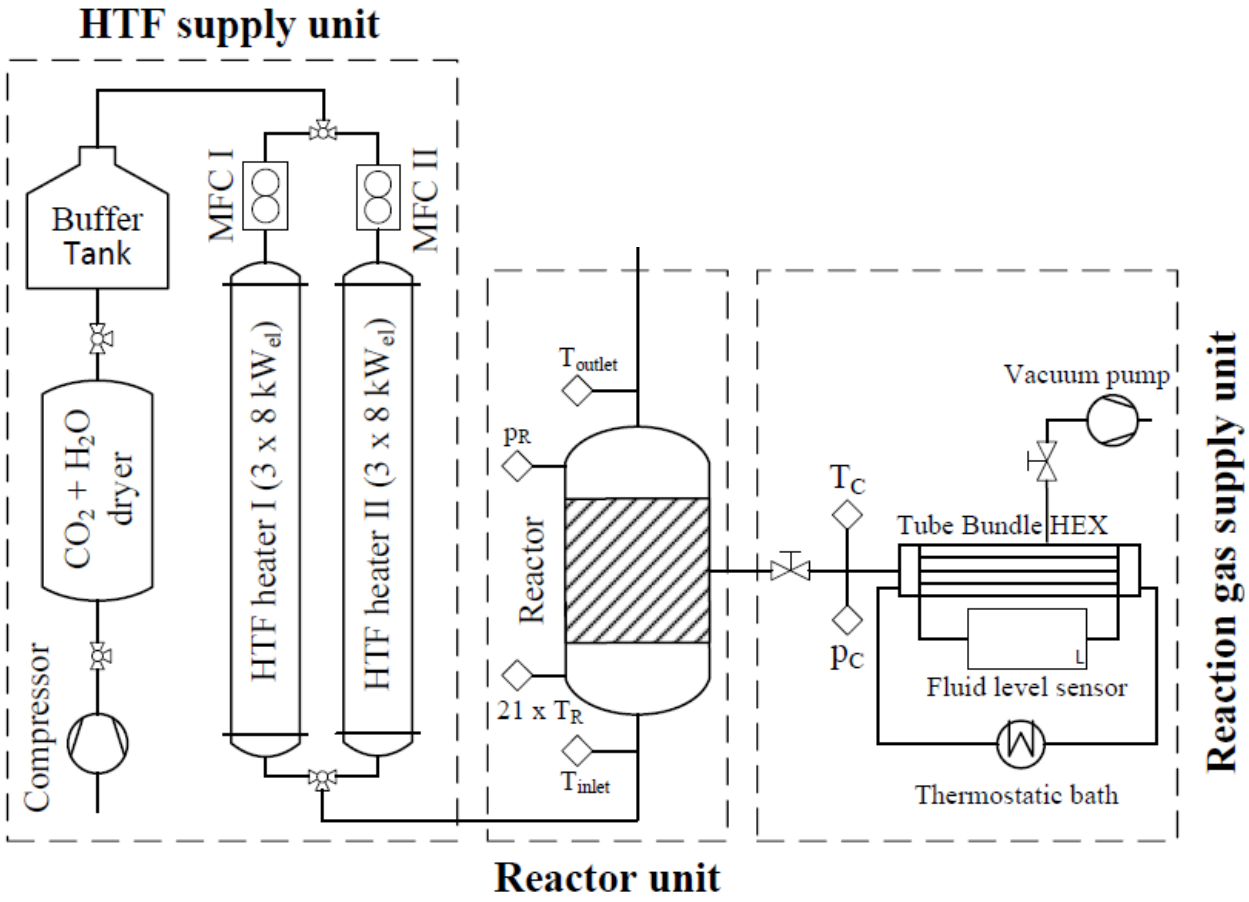

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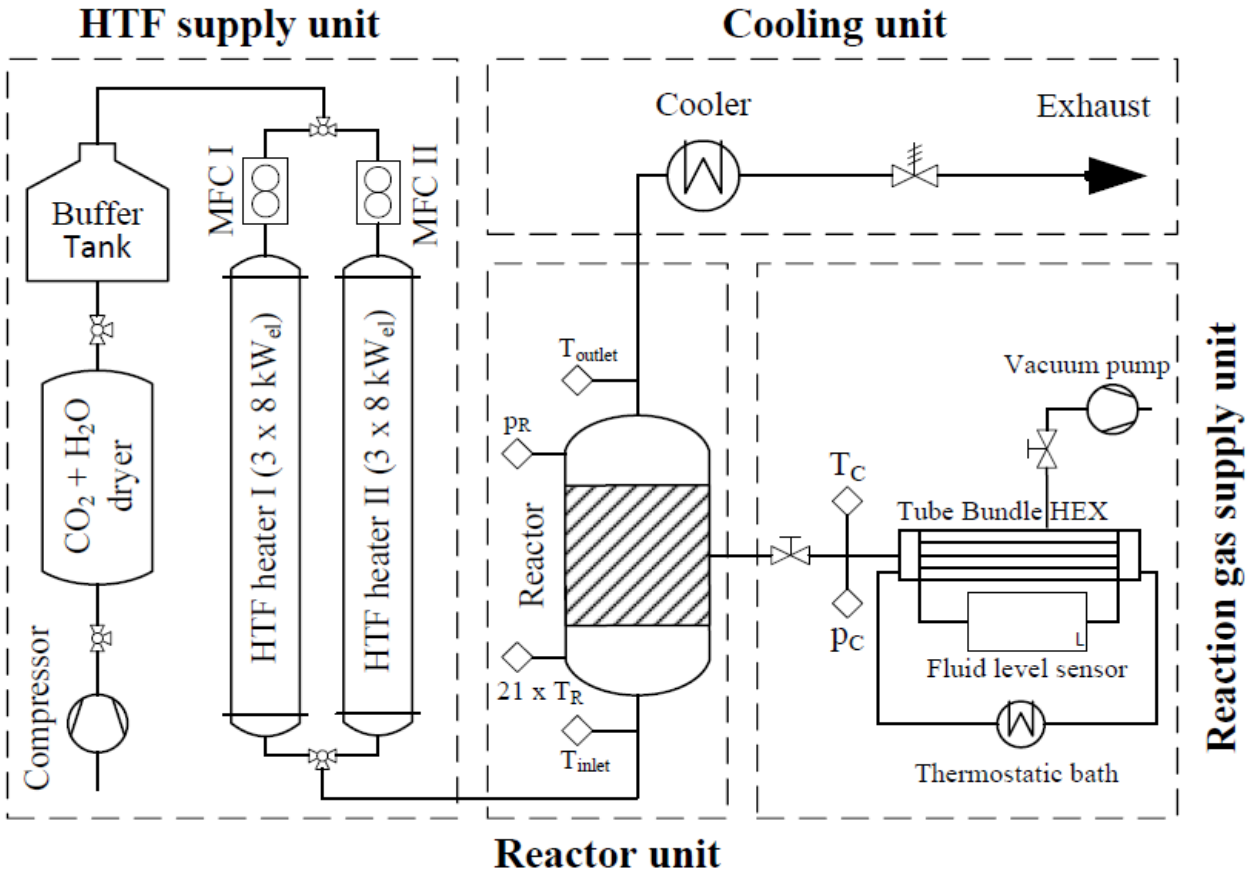

M. Schmidt et al., Applied Thermal Energy 62 (2014)

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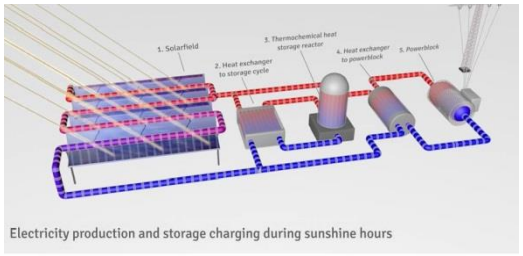
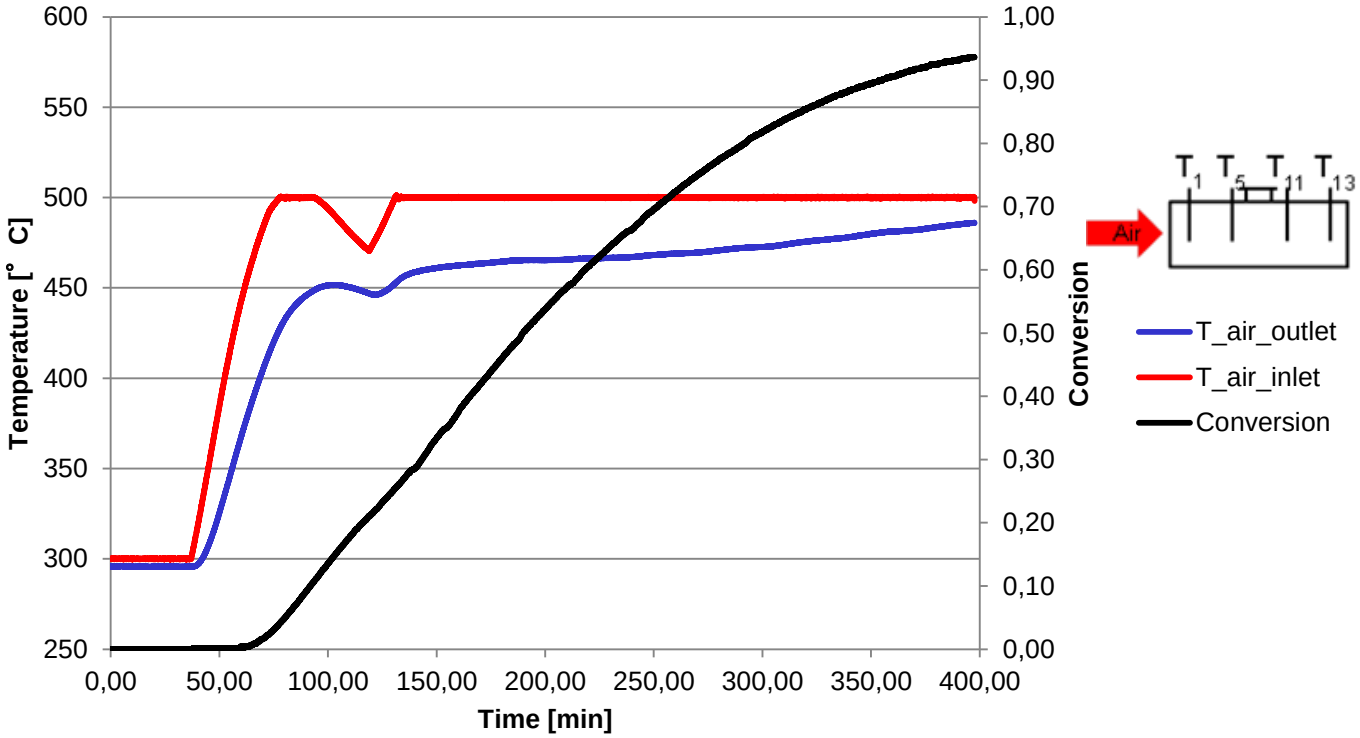


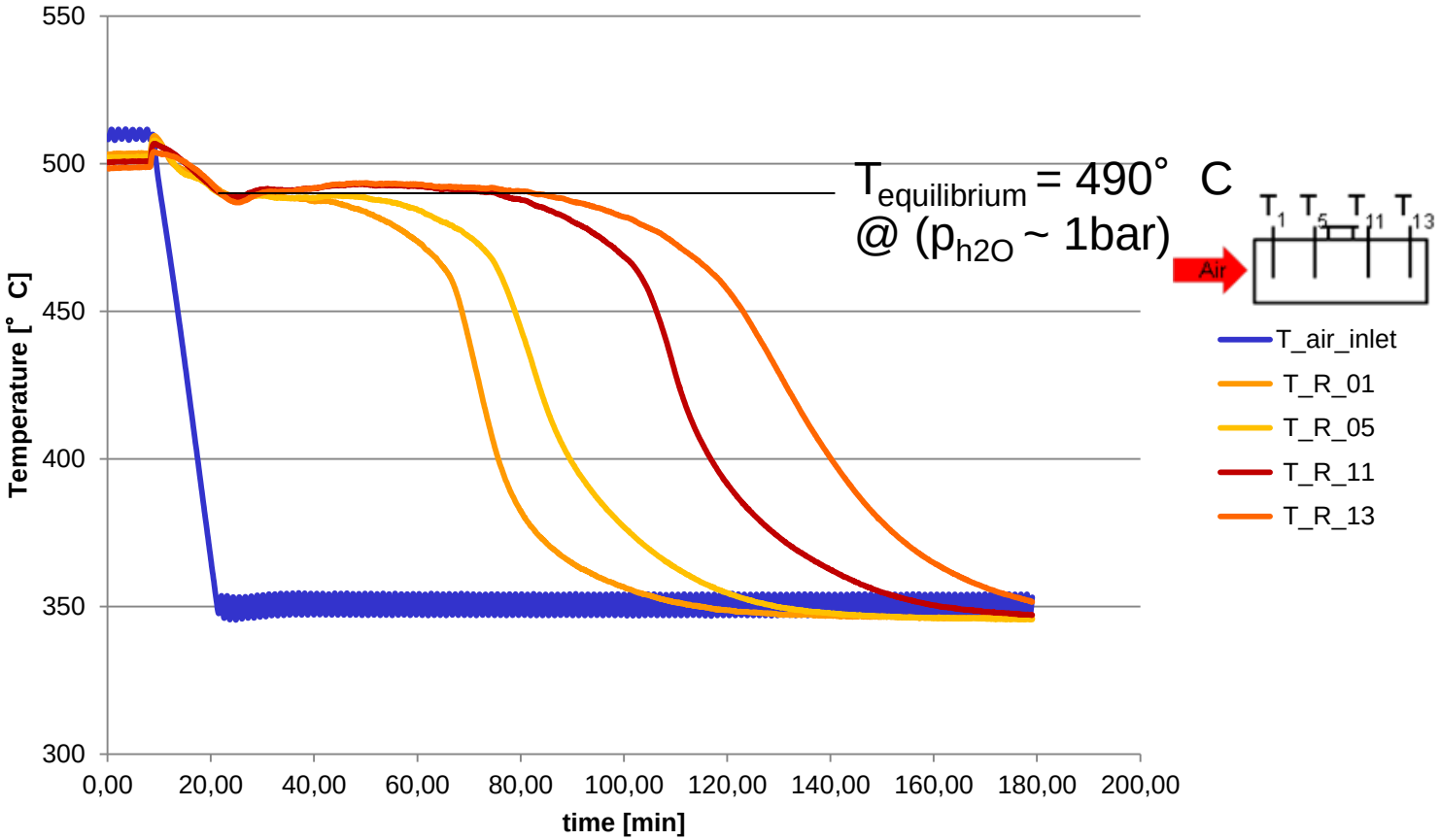
Charging Mode

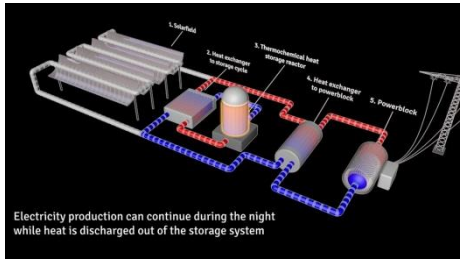
dehydration of $Ca(OH)_2$ at p_{h2O} = 100mbar



Buffer Storage Mode

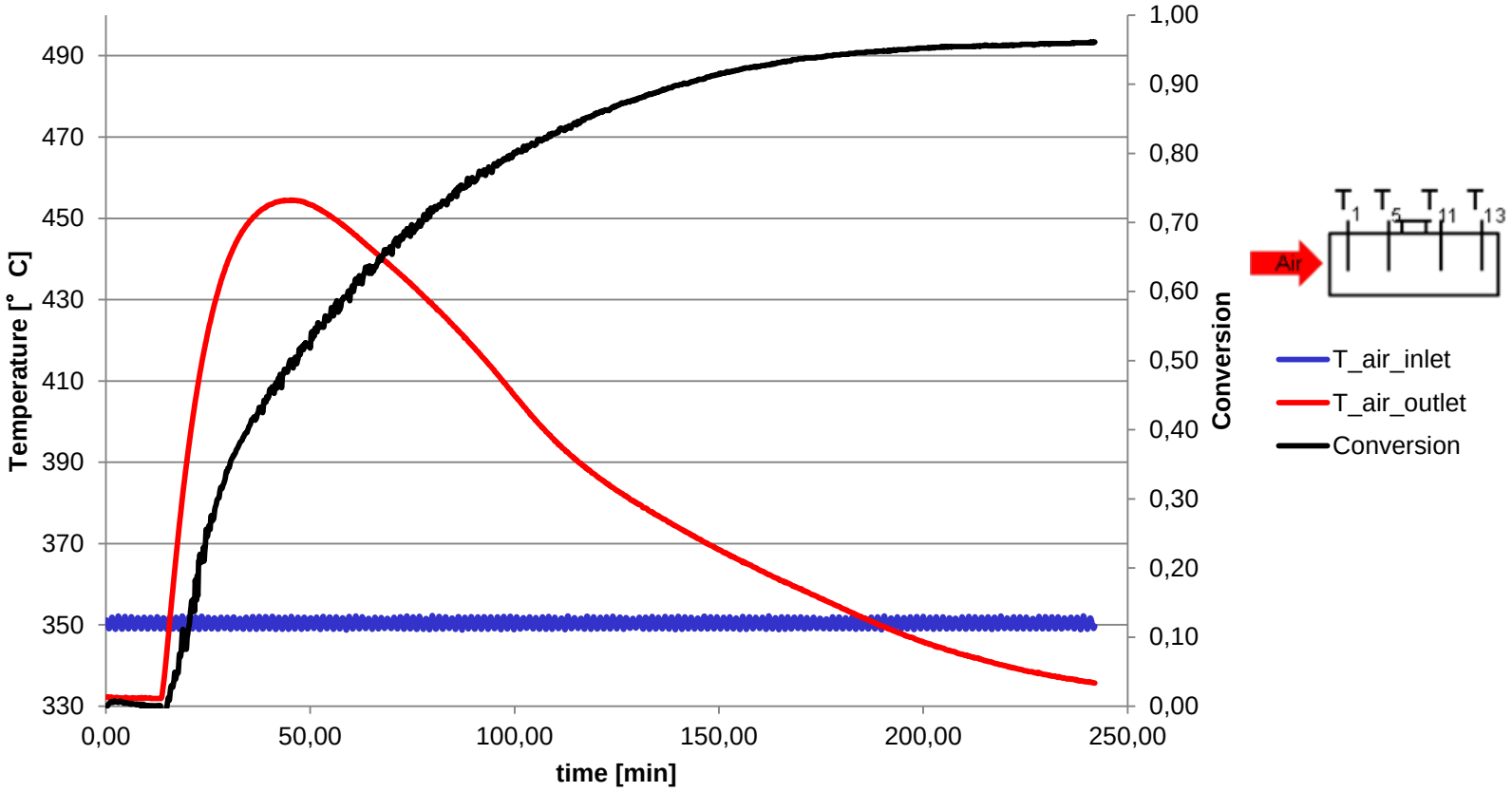
droping inlet temperature, hydration of CaO at 1 bar vapor



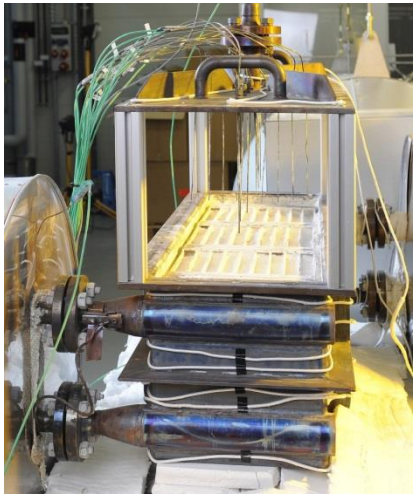


Heat Generation Mode

Hydration of CaO, starting temperature of 350° C



Summary and Outlook

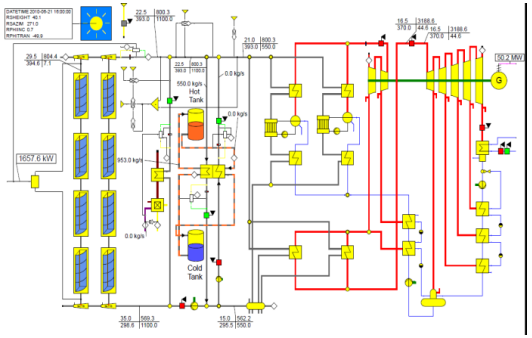


✓$CaO / Ca(OH)_2$ combines
low material costs with high storage density

✓Reactor for 25kg (10 kWh) and 10 kW in operation

✓Charging at temperatures >400° C demonstrated

✓Discharging at adjustable temperatures (400-600° C)
and in different operation modes possible



– Development of integration strategies
(CSP and other applications)

– Performance evaluation through system modeling

– Material modifications to improve conveyance

Thank you!

TCS Power
thermochemical energy storage

SEVENTH FRAMEWORK PROGRAMME

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